Name: ______________________ Date: ______________

PRACTICE 7.3

Specific Heat

READ

Specific heat is defined as the amount of heat energy needed to raise 1 gram of a substance 1°C in temperature.

- Specific heat values are used in the heat equation is:

$$Q = mC_p(T_2 - T_1)$$

where Q is the heat energy (joules), m is the mass of the substance (kilograms), C_p is the specific heat of the substance (J/kg°C), and $(T_2 - T_1)$ is the change in temperature (°C)

- The higher the specific heat, the more energy is required to cause a change in temperature. Substances with higher specific heats require more loss of heat energy to experience a lowering of their temperature than do substances with a low specific heat. Some sample specific heat values are presented in the table below:

Material	Specific Heat (J/kg °C)
water (pure)	4,184
aluminum	900
steel	470
silver	235
oil	1,900
concrete	880
glass	800
gold	129
wood	2,500

- Water has the highest specific heat of the listed types of matter. This means that water is slower to heat but is also slower to lose heat.

EXAMPLE

- How much energy is required to heat 35 grams of gold from 10°C to 50°C?

Looking for	Solution
The heat energy in joules to heat 35 grams of gold by 40°C.	$Q = mC_p(T_2 - T_1)$ $Q = (0.35\text{ kg})\left(129\frac{\text{J}}{\text{kg}\cdot{}^\circ C}\right)(50^\circ C - 10^\circ C)$ $Q = (0.35\text{ kg})\left(129\frac{\text{J}}{\text{kg}\cdot{}^\circ C}\right)(40^\circ C)$ $Q = 1{,}806\text{ joules}$ To produce the necessary change in temperature, 1,806 joules of heat energy need to be put into this sample of gold.
Given Mass = 35 grams = 0.35 kilogram Specific heat of gold = 129 J/g°C T_2 = 50°C and T_1 =10°C	
Relationship $Q = mC_p(T_2 - T_1)$	

PRACTICE

Using the heat formula and the table of specific heat values, solve the following heat problems.

1. A 0.5-kilogram piece of aluminum increases its temperature 7°C when heat energy is added. How much heat energy produced this change in temperature?

2. A volume of water has a mass of 0.5 kilogram. If the temperature of this amount of water was raised by 7°C, how much heat energy is produced?

3. How much heat energy is required to raise the temperature of 1 kilogram of steel by 10°C?

4. How much heat energy is needed to raise the temperature of 100-liters of water from 10°C to 25°C? Note: One liter of water has a mass of one kilogram.

5. When 1,500 joules of energy is lost from a 0.12-kilogram object, the temperature decreases from 45°C to 40°C. What is the specific heat of this object? Of what material is the object made?

6. What is the specific heat of a material that gains 600 joules of energy when a 0.25-kilogram object increases in temperate by 3°C? What is this material?

7. A liquid with a specific heat of 1,900 J/kg·°C has 4,750 joules of heat energy is added to it. If the temperature increases from 20°C to 30°C, what is the mass of the liquid?

8. What is the mass of a block of concrete that gains 52,800 joules of energy when its temperature is increased by 5°C?

9. A scientist wants to raise the temperature of a 0.10-kilogram sample of glass from –45°C to 15°C. How much heat energy is required to produce this change in temperature?

10. A person wishes to heat pot of fresh water from 20°C to 100°C in order to boil water for pasta. They calculate that their pot holds 2 kilograms of water and that they would need to apply 669,440 joules of heat energy to produce the desired temperature change. Are the person's calculations correct? Defend your answer and demonstrate all relevant calculations.

11. A 0.25-kilogram sample of aluminum is provided with 5,000 joules of heat energy. What will be the change in temperature of this sample of aluminum?

12. What is the change in temperature for a 2-kilogram mass of water that loses 8,500 joules of energy?

13. Which of the substances listed in the table on the first page would heat up more quickly if an equal amount of heat energy were applied to all of the substances at the same time? Explain your answer.

14. Which of the substances listed in the table on the first page would you choose as the best insulator (substance that requires a lot of heat energy to experience a change in temperature)? Explain your answer.

15. Which substance—wood or steel—is the better conductor? A conductor is a material that requires very little heat energy to experience a change in temperature. Explain your answer.

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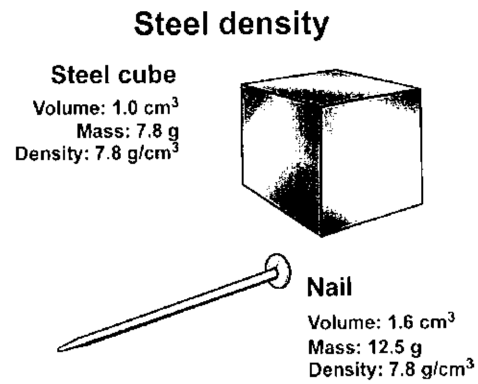
PRACTICE 8.1

Density

READ

- The density of a substance does not depend on its size or shape. As long as a substance is homogeneous, the density will be the same. This means that a steel nail has the same density as a cube of steel or a steel girder used to build a bridge.



- The formula for density is: $\text{density} = \frac{\text{mass}}{\text{volume}}$
- One milliliter takes up the same amount of space as one cubic centimeter. Therefore, density can be expressed in units of g/mL or g/cm^3. Liquid volumes are most commonly expressed in milliliters, while volumes of solids are usually expressed in cubic centimeters.
- Density can also be expressed in units of kilograms per cubic meter (kg/m^3).
- If you know the density of a substance and the volume of a sample, you can calculate the mass of the sample. To do this, rearrange the equation above to find mass: $\text{volume} \times \text{density} = \text{mass}$
- If you know the density of a substance and the mass of a sample, you can find the volume of the sample. This time, you will rearrange the density equation to find volume: $\text{volume} = \frac{\text{mass}}{\text{density}}$

EXAMPLES

Example 1: What is the density of a block of aluminum with a volume of 30.0 cm^3 and a mass of 81.0 grams?

$$\text{density} = \frac{81.0\ \text{g}}{30.0\ \text{cm}^3} = \frac{2.70\ \text{g}}{\text{cm}^3}$$

Answer: The density of aluminum is 2.70 g/cm^3.

Example 2: What is the mass of an iron horseshoe with a volume of 89 cm^3? The density of iron is 7.9 g/cm^3.

$$\text{mass} = 89\text{cm}^3 \times 7.9\frac{\text{g}}{\text{cm}^3} = 703\ \text{grams}$$

Answer: The mass of the horseshoe is 703 grams.

Example 3: What is the volume of a 525-gram block of lead? The density of lead is 11.3 g/cm^3.

$$\text{volume} = \frac{525\ \text{g}}{11.3\frac{\text{g}}{\text{cm}^3}} = 46.5\ \text{cm}^3$$

Answer: The volume of the block is 46.5 cm^3.

PRACTICE

1. A solid rubber stopper has a mass of 33.0 grams and a volume of 30.0 cm^3. What is the density of rubber?
2. A chunk of paraffin (wax) has a mass of 50.4 grams and a volume of 57.9 cm^3. What is the density of paraffin?
3. A marble statue has a mass of 6,200 grams and a volume of 2,296 cm^3. What is the density of marble?
4. The density of ice is 0.92 g/cm^3. An ice sculptor orders a one cubic meter block of ice. What is the mass of the block? Hint: 1 m^3 = 1,000,000 cm^3. Give your answer in grams and kilograms.
5. What is the mass of a pure platinum disk with a volume of 113 cm^3? The density of platinum is 21.4 g/cm^3. Give your answer in grams and kilograms.
6. The density of seawater is 1.025 g/mL. What is the mass of 1.000 liter of seawater in grams and in kilograms? (Hint: 1 liter = 1,000 mL)
7. The density of cork is 0.24 g/cm^3. What is the volume of a 240-gram piece of cork?
8. The density of gold is 19.3 g/cm^3. What is the volume of a 575-gram bar of pure gold?
9. The density of mercury is 13.6 g/mL. What is the volume of a 155-gram sample of mercury?
10. Recycling centers, for example, use density to help sort and identify different types of plastics so that they can be properly recycled. The table below shows common types of plastics, their recycling code, and density. Use the table to solve problems 10a -d.

Plastic name	Common uses	Recycling code	Density (g/cm^3)	Density (kg/m^3)
PETE	plastic soda bottles	1	1.38-1.39	1,380 - 1,390
HDPE	milk cartons	2	0.95-0.97	950 - 970
PVC	plumbing pipe	3	1.15-1.35	1,150 - 1,350
LDPE	trash can liners	4	0.92-0.94	920 - 940
PP	yogurt containers	5	0.90-0.91	900 - 910
PS	cd "jewel cases"	6	1.05-1.07	1,050 - 1,070

a. A recycling center has a 0.125 m^3 box filled with one type of plastic. When empty, the box had a mass of 0.755 kilograms. The full box has a mass of 120.8 kilograms. What is the density of the plastic? What type of plastic is in the box?

b. A truckload of plastic soda bottles was finely shredded at a recycling center. The plastic shreds were placed into 55-liter drums. What is the mass of the plastic shreds inside one of the drums? Hint: 55 liters = 55,000 milliliters = 55,000 cm^3.

c. A recycling center has 100 kilograms of shredded plastic yogurt containers. What volume is needed to hold this amount of shredded plastic? How many 10-liter (10,000 mL) containers do they need to hold all of this plastic? Hint: 1 m^3 = 1,000,000 mL.

d. A solid will float in a liquid if it is less dense than the liquid, and sink if it is more dense than the liquid. If the density of seawater is 1.025 g/mL, which types of plastics would definitely float in seawater?